Combined Transformer and Prefabricated Substation

Technical field

This invention relates to cubicle type substation, especially to combined transformer and prefabricated substation.

Background of the Invention

Cubicle type substation is widely used in power transmission and distribution industry, including combined transformer and prefabricated substation. The introduction is as follows:

Combined Transformer

The combined transformer is a term from China Machinery Industry Standard JB/T 10217-2000"Combined Transformer". Since the technology of this product comes from U.S.A, the combined transformer is also called "American Cubicle Transformer".

In American National Standard ANSI/IEEE C57.12.26, the combined transformer is called "three Phases Compartment-Type Pad-Mounted Transformers". In above standard, in Chinese patent such as "New type of combined transformer" (Patent No. 00217238.0) and in the product catalog of American GE company and Shanghai Zhixin Company, the typical structure of combined transformer is shown as Fig.1, which mainly includes transformer chamber, HV load switch, protection fuse, radiator, HV chamber and LV chamber etc, featuring:

1. Transformer chamber, HV chamber, LV chamber and radiator are compact in a plane arrangement on the platform pedestal.
2. Transformer, HV load switch, protective fuse, HV & LV connection wire and transformer oil are set in the transformer chamber.
3. Incoming LV cable at the bottom of LV chamber is connected to transformer output end in transformer chamber.
4. Incoming HV cable at the bottom of HV chamber is connected to transformer input end in transformer chamber.
5. The radiator is located at the side wall of the transformer chamber.
6. Instrument, cable plug, fuse stand and auxiliary equipment are located in HV chamber or LV chamber;

Fig.2 is "Triangle shape" plan layout and main circuit diagram showing the relation between transformer chamber, HV chamber and LV chamber. Fig.3 shows "Parallel" plan layout or other plan layout.

As the requirement for urban environment beautification improves, people hope to reduce the area occupied by combined transformer. The American cubicle type transformer has following shortages in structure feature:

1. Large occupied area: For combined transformer arranged in plane shown in Fig.1, 2 and 3, when it is installed on the ground, the total occupied area is the sum of the four since the transformer chamber, HV chamber, LV chamber and

radiator are arranged in a plane.

2. If the combined transformer is completely buried underground, the equipment operation and maintenance will be inconvenient. Also, it is not good for auxiliary equipment such as instrument with high requirement on waterproofing. Furthermore, it will cause difficulty for the radiation of large capacity of transformer.

Prefabricated substation

In order to meet the requirement which is to arrange power supply cable underground in downtown districts and busy streets in power transmission and application, the prefabricated substation which can transfer HV (1-53KV) into LV (0.4KV) is widely used.

Chinese National Standard GB/T17467-1998"HV/LV Prefabricated Substation" and the International Electrician Committee IEC1330:1995 "HV/LV Prefabricated Substation" stipulate: The prefabricated substation which mainly consists of transformer, HV switch equipment and control equipment, LV switch equipment and control equipment, related internal connection wire (cable, bus bar and others) shall be enclosed with a common casing or a group of casings. The common casing or a group of casings of prefabricated substation is normally divided into three compartments: HV chamber, LV chamber and transformer chamber. In Mr.Hu Zhaoming and Shen Wei's "Cubicle Type Substation" electric power equipment 2000 (1) and William Stemmons "Packaged Power Control Assemblies" Copyright Material IEEE Paper No. PCIC 84-11 technical document and Chinese patent "Prefabricated Substation in Basement" (Patent No. 00205369.1), all the three compartments of prefabricated substation with existing open technology are in a plane, parallel and compact layout. Referring to Figs.12, 13 and 14, a "Parallel" layout and two "Triangle" layouts can be seen, which are placed on the ground or all or part of them are installed underground. The prefabricated substation is different from the conventional civil constructed substations, its parts including transformer, HV & LV switch, control equipment, auxiliary equipment as well as the casing are assembled into a complete set of equipment in the factory. Then, the whole or part of the equipment is carried to the site, see Fig.10. After site installation and connection of external incoming & outgoing cables, it can be put into use.

With the improvement of urban environment beautification requirement, the shortage of existing prefabricated substation has been clearly shown: Large occupied area – since the three compartments are arranged in parallel in a plane, the occupied area is the sum of the total three; large occupied space—this is because the space needed for the whole installation is great. If part of it is installed underground, the waterproof requirement for HV & LV chamber will be extremely high and the equipment running and maintenance will be inconvenient. Meanwhile, the radiation for transformer chamber with high heat output will be difficult, also, the natural ventilation and radiation is hard to be realized. And the construction cost for basement is high, if the whole substation is buried underground, an artificial radiation ventilation facility needs to be provided.

Summary of the Invention

An object of the present invention is to provide a cubicle type substation with good radiating effect.

The other object of the present invention is to provide a combined transformer and a prefabricated substation with small occupation area and convenient operation.

The combined transformer including transformer chamber, LV chamber, HV chamber and radiator features: The radiator has hollow heat pipe in which heat transferring medium is filled. One end of the heat pipe is inserted into the transformer chamber, the other end thereof is provided with radiating fins; LV chamber is set above the transformer chamber while HV chamber is set at the side of transformer chamber. The transformer chamber and HV chamber are buried underground. The radiating fin is set above the transformer chamber. The traditional liquid radiating fin is located at the side of the transformer chamber.

The prefabricated substation including transformer chamber, transformer installed in the transformer chamber, switch room with LV and HV chamber, radiator, features: the radiator has hollow heat pipe in which heat transferring medium is filled. One end of the heat pipe is inserted into the transformer, while the other end is provided with radiating fins; the radiating fins are at the outside of the switch room. The switch room is set above the transformer chamber. The HV & LV chamber each has a door. The transformer chamber is enclosed with ground pit and cover plate.

In above combined transformer and prefabricated substation, the heat transferring capacity of the heat pipe is great, with long service life, high reliability and small volume. The radiating effect has been greatly improved. Furthermore, it changed the traditional layout, i.e., the transformer chamber, LV chamber and HV chamber are arranged in a parallel and compact way in the same plane. The transformer chamber with large volume, HV chamber with less operation and radiator at the bottom are set at the lower layer; LV chamber with frequent operation, maintenance and high waterproof requirement as well as top radiator are set at the upper layer; in application, the lower layer is set underground, and for the upper layer above the ground, the occupied area has been reduced 60-70% compared with traditionally arranged combined transformer in a plane. The prefabricated substation with switch room set above the transformer room can reduce the occupied area 30-40%. In addition, since the switch room for the prefabricated substation is set above the transformer room and above ground, the waterproof and damp-proof function can be realized, meanwhile, the doors for HV & LV chamber are easy to be opened, thus, it is convenient for equipment operation and maintenance in HV & LV chamber. The transformer room is set underground so that natural ventilation and radiation for the transformer can be realized via heat pipe radiator. The oil-immersed transformer has high running reliability and good waterproof performance, hence, 20 years' free of maintenance can be realized.

Brief Description of the Drawings

Fig.1 is a typical structural view of an existing combined transformer.

Fig.2 is a "Triangle" plan layout and main circuit diagram of the combined transformer in Fig.1.

Fig.3 is a "Parallel" plan layout and main circuit diagram of the combined transformer in Fig.1.

Fig.4 is a solid structural layout of a combined transformer of the present invention.

Fig.5 is another solid structural layout of a combined transformer of the present invention

Fig.6 is a structural view of the top heat pipe radiator.

Fig.7 is a structural view of the socket, operating handle, regulating handle in LV chamber of combined transformer.

Fig.8 is a structural view of the socket, operating handle, regulating handle in HV chamber of combined transformer.

Fig.9 is a schematic structural view of the combined transformer of the present invention installed in the ground pit.

Fig.10 is a structural view of the existing prefabricated substation by overall transportation and hoisting.

Fig.11 is a structural layout and main circuit diagram for HV & LV chamber and transformer chamber in existing prefabricated substation.

Fig.12, 13, 14 are the three kinds of plan layout for HV & LV chamber and transformer chamber in existing prefabricated substation, respectively.

Fig.15 is a structural layout and main circuit diagram for the prefabricated substation of the present invention.

Fig.16 is a plan layout of the prefabricated substation of the present invention.

Fig.17 is a solid structural layout for the prefabricated substation of the present invention.

Fig.18 is a structural view for heat pipe radiator.

Detailed Description of the Preferred Embodiments

The following is the further description with two practical examples for this cubical type substation invented. See reference drawings.

Combined transformer

Referring to Fig.4-8, the combined transformer of the present invention includes transformer chamber 1, LV chamber 2, HV chamber 3, top radiator 4, bottom radiator 5, platform stand 6, transformer 13, transformer oil 14, protective fuse 15, HV load switch 16, tap switch 17, socket 24 for protective fuse 15, operating handle 25 for HV load switch 16, regulating handle 26 for tap switch 17, LV outgoing terminal 20, HV cable socket 27.

The top radiator 4 is set above the transformer chamber 1 (Fig.4). Here, a split-type structure can also be adopted for the top radiator 4 and transformer chamber 1 (Fig.5). The top radiator 4 includes heat pipes 7 and radiating fins 10. Many

arrangement styles are available for the top radiator 4. The Heat pipes 7 and radiating fins 10 can be set at one side or three sides of LV chamber 2, or can also be set on the top of the LV chamber 2. The top radiator 4 is implemented by the heat pipes 7 connecting to the transformer chamber 1, and the radiating fins 10 are provided on the heat pipes 7 to improve the radiating effect of the heat pipes 7.

The heat pipes 7 consist of steel or copper pipes, the radiating fins 10 are made of steel plates or aluminum plates, the heat pipes 7 are the radiating fins 10 are welded together. The lower section of the heat pipes 7 can be inserted into the transformer chamber 1 to contact the transformer oil 14 and improve the heat absorption effect for heat pipes 7. The heat pipes 7 can also be welded to a side of transformer chamber 1 so as to reduce the influence to the equipment in transformer chamber 1. The heat pipes 7 transfer the heat in transformer chamber 1 to radiating fins 10 via the medium in heat pipe cavity 11. The radiating fin radiates the heat into the atmosphere above the ground to solve the heat problem since the transformer chamber 1 is buried underground. The bottom radiator 5 is a conventional transformer oil radiator.

The transformer oil 14 is filled up in transformer chamber 1. Not only the transformer 13 is immersed in the oil but also the protective fuse 15, HV load switch 16, tap switch 17 are immersed in the oil. The transformer oil is fully used to realize insulation.

The socket 24 for protective fuse 15, operating handle 25 for HV load switch 16, regulating handle 26 for tap switch 17 are set in LV chamber 2 (Fig.7), thereby the operation for combined transformer in LV chamber 2 is convenient.

In order to reduce the volume of the upper layer, the socket 24 for protective fuse 15, operating handle 25 for HV load switch 16, regulating handle 26 for tap switch 17 can also be set in HV chamber 3 (Fig.8). During the operation, the operator needs to go down into the pit and work around the pit.

The LV outgoing terminal 20 is located in LV chamber 2. HV cable socket 27 is located in HV chamber 3.

An insulation layer 30 is set between the LV chamber 2 and transformer chamber 1 or radiating fin 10 to prevent the heat in transformer chamber 1 or radiating fin 10 from entering LV chamber 2.

The bottom radiator 5 is set at the side of the transformer chamber 1 to improve the radiating effect of transformer chamber 1, the heat generated thereof can be transferred into the pit and eliminated out along the periphery of the pit.

A door 8 is set at a side of the LV chamber 2 so as to open it easily and enter LV chamber 2 for operation. Under the door 8 is underground cable entry 9, which is used for LV cable incoming.

In the LV chamber 2 are LV switch 21, oil temperature gauge 22 and oil level meter 23, which are used to control the running status.

See Fig 6, the transformer chamber 1 includes sealed box 12 welded with steel plate, the box 12 contains transformer 13, transformer oil 14, protective fuse 15, HV load switch 16 and tap switch 17, and outside the box 12 is pressure relief valve 18, the selection and installation for these parts are the same as the conventional ones; wherein the socket 24 for protective fuse 15, operating handle 25 for HV load switch

16, regulating handle 26 for tap switch 17 are arranged in LV chamber 2 at upper layer for easy operation.

See Fig 7 for a front view and section view, LV chamber 2 is made into box 19 with steel plate; Box 19 is provided with a door 8 and underground cable entry 9; LV outgoing line from transformer 13 is introduced to LV outgoing terminal 20 via conductor; Power supply for LV outgoing terminal 20 will go out from underground cable entry 9 through cable after passing LV switch 21; Oil temperature gauge 22 and oil level meter 23 are installed in the box 19 for easy observation; Oil temperature and level probe 31 are in the transformer oil 14. The HV chamber 3 has waterproof HV cable socket 27, a steel partition 28 for safety protection is provided above the cable socket 27, and a HV cable entry 29 is located outside of the cable socket 27.

As can be seen from Fig.8 for a front view and section view, another type of HV chamber 3 includes the socket 24 for protective fuse 15, operating handle 25 for HV load switch 16, regulating handle 26 for tap switch 17; HV cable socket 27 adopts upper/lower plug-in/out structure installed in vertical plane, the structure simplifies the fabrication of box 12 and is convenient for HV cable installation. The difference with Fig.7 is: the socket 24 for protective fuse 15, operating handle 25 for HV load switch 16 and regulating handle 26 for tap switch 17 are installed in HV chamber 3.

Referring to Fig. 9, in operation, a ground pit 32 can be built under the ground, the lower parts, such as transformer chamber 1, HV chamber 3 etc are put into the ground pit 32, and the upper parts such as LV chamber 2 etc. are exposed above the ground. The ground pit is provided with a cover 33 at the opening thereof; Open the ground pit cover plate 34, the installation for this combined transformer invented, connection of cable and operation & maintenance of partial equipment can be performed.

Based on the design principle, the transformer chamber, bottom radiator and HV chamber at lower layer are made of anti-corrosive steel plate with surface anti-corrosive treatment; Grid air inlet is set on the cover plate of the bottom radiator; The oil-immersed transformer with high reliability can realize waterproof function and 20 years' of free of maintenance; Incoming HV cable adopts all-sealed plug-in/out connector and can be safely operated on hot line under the water; HV chamber does not need watertight function so that the cost is reduced.

In accordance with the design principle, optionally, only one of the top radiator and the bottom radiator can be used based on different radiation requirement. If the underground transformer fails, similar to conventional combined transformer, the replacement method for the whole body can be adopted so that a rapid and convenient maintenance can be realized to ensure the power supply.

This invention adopts an upper/lower overlap structure for transformer chamber, LV chamber, HV chamber and top & bottom radiator, i.e., the half of waterproof transformer chamber, HV chamber and bottom radiator which are free of maintenance and operation are buried underground; LV chamber and top radiator which have high waterproof requirement and need operation and maintenance are placed above the ground. On the premise of suiting for running & maintenance, meeting site

installation requirement and not increasing costs, the occupied area by combined transformer has been reduced in a maximum degree and in a optimum way so as to reach the goal of environment beautification.

Prefabricated substation

In Figs. 15-18, the prefabricated substation consists of switch room 1', transformer chamber 2' and transformer 3' installed in transformer chamber 2'; In the switch room 1' are HV chamber 6' and LV chamber 7'; The outside of the switch room 1' is heat pipe radiator 4'; The switch room 1' is set above the transformer chamber 2'; Heat pipe radiator 4' is connected on the transformer 3'; In the heat pipe radiator 4' is a group of steel heat pipes12' with heat transferring medium 13' filled up inside; The lower end of heat pipe 12' is connected to the inside of transformer 3', while the upper end thereof is provided with metal radiating fins 14'; Radiating fins 14' are located at the outer side of switch room 1'; Above the switch room 1' and heat pipe radiator 4' is tilting top cover 8'; Door 9' is available for HV chamber 6' and LV chamber 7'; In the transformer chamber 2' is concrete ground pit 10' with steel cover plate 5' covering above; cable entry opening 11' is set at the side of ground pit 10'. The transformer 3' is an oil-immersed one, the connection between transformer HV & LV terminals and HV chamber 6' and LV chamber 7' uses waterproof cable, and the waterproof socket is used for cable gland. During the installation, the transformer chamber 2' with oil-immersed transformer 3' installed is buried underground; Place the switch room 1' which is not easy to perform waterproofing and needs maintenance above the transformer chamber and expose it above the ground for easy maintenance and waterproofing. During the operation, a natural ventilation and radiation for oil-immersed transformer 3' can be realized via heat pipe radiator 4'. Therefore, on the premise of meeting the requirement of normal running and maintenance for the substation, the occupied area has been reduced so that the goal to beautify the environment is achieved.

During the installation and application, just build a ground pit under the ground and place the lower parts including such as transformer chamber with installed transformer into the pit and the upper parts including such as LV chamber above the ground; Cover plate is set at the ground pit opening; Open the ground pit cover plate to carry out transformer installation, cable connection and maintenance to some of the equipment. If the transformer in lower parts underground fails, similar to existing substation, maintenance can be quick and convenient and power supply can be ensured.